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"THE WEATHER:"

A PRACTICAL GUIDE TO ITS CHANGES,

SHOWING

SIGNAL SERVICE SYSTEM, AND HOW TO FORETELL LOCAL WEATHER.

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PREFACE.

This little book aims to be simply what its title implies: *a practical guide to weather changes*, and a help to a better understanding of the weather reports and predictions daily issued.

It is not proposed to consider any of the conflicting scientific theories, many of them still mere assumptions, that have been accepted as explaining the phenomena daily presented in our atmosphere.

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THE WEATHER.

IMPORTANCE OF WEATHER KNOWLEDGE.

THE *London Times* has said "the weather is by no means a subject which should be regarded merely as a matter of conversation for the multitudes of people who find it difficult to talk about any thing else. The subject is, in reality, one of great national importance; of far more importance than many others which occupy the time and the thoughts of the public; and it is only neglected on account of the obscurity behind which the causes of weather changes have been hitherto concealed, and of the consequent apparent futility of discussing them. If any scientific investigation could bring the subject of weather changes within the region of actual knowledge, so that reasonable forecast might be made concerning them, it would at once become manifest that scarcely any other subject would vie with them in universality of interest. The power of foreseeing the weather of the next few days would do much, the power of foreseeing the weather of the next season would do almost every thing, to take away from agriculture the uncertainty which is now its greatest hinderance; and a bad harvest season would then no longer, as at present, entail upon the nation a loss which must be estimated by millions."

The accuracy attainable in foretelling the weather of at least the next few days, the forecasts being based upon local indications taken in connection with the general information furnished by the Signal Service, will agreeably surprise any one who will test the matter for himself.

In our active, working life, who does not consult the weather, and what branch of every-day life and its varied pursuits is not influenced and affected by its changes? The

practical application of weather knowledge to all classes of industry, to all professions, handicrafts, and processes of animal and vegetable life, is steadily increasing. Physicians and boards of health are enabled, from telegraphic weather reports, to detect dangerous atmospherie conditions, to investigate the origin and spread of diseases and epidemics, and to give timely warnings or hopeful encouragement, based on the knowledge of coming changes. The subtile, mysterious influence of the weather governs and controls us, and, because we pay so little attention to its changes, sends many of us to our long home.

The important question, will it be clear or cloudy, warm or cold, rain or snow, on the morrow, involves so much of our health and comfort, as well as success, in nearly every practical walk of life, that all should be, as all may be, able to answer it for themselves. That a local, isolated observer, without instruments, but with some general knowledge of the elements of meteorology, and with the aid of telegraphic reports of weather conditions, especially to the westward, whence most of our weather comes, can foresee his own weather for the morrow, is beyond doubt. No farmer need suffer loss or damage from the coming rain; no merchant need risk his perishable cargo; no speculator his money, and no traveler his safety and comfort.

It is in the hope of helping to a popular understanding of the subject that these pages are written, and any thing beyond the mere setting forth of established rules and facts does not come within the scope of the book.

WEATHER PROPHETS.

Weather prophecy, that covers a period of time in advance, and that specifies certain dates in the future upon which certain conditions are, or are even likely to prevail, is simply a delusion, and the alleged prophets should be regarded as materialized spooks and noisy cranks, who blow their horns, of greater or less dimensions, emitting sounds signifying nothing. Some of these manage, by extensive advertisement and an occasional chance hit, to attract the at-

tention of the over credulous; but they sooner or later fade away and disappear from public attention.

No man can, by any reasoning whatever, or upon any hypothesis, foretell the weather beyond a few days, or rarely a week in advance. Long range predictions, whether based on the position of the planets, the influence of the moon or of sun spots, or on the assumed law of periodicity, are unreliable, and amount simply to good, bad, or indifferent guesswork. It is not complimentary to the intelligence of the times, or the diffusion of knowledge, that the absurd vaticinations of the professional weather wizards should still be accepted with more or less credibility. Failures do not seem to have any effect upon the minds of the unthinking, while a chance success is heralded throughout the land, even by the press, whose business it should be to be intelligent. Arago, a French astronomer, said that no scientific man, who cared for his reputation, would venture upon a weather prediction. And yet the leading weather prophets of our time are men who base their predictions upon the occurrence of astronomical events; upon the theory that the planets exercise a controlling influence over the weather of our earth; that planetary perihelion and aphelion passages, oppositions, and conjunctions, produce changes and interruptions in the electric currents undulating between them, causing various grades of meteoric disturbances in our atmosphere.

SIGNAL SERVICE SYSTEM.

The only reliable, as it is the only reasonable, system of forecasting the weather, is that of our Signal Service. But, while the Weather Bureau at Washington is making great progress in reducing meteorology to an exact science, the geographical areas for which predictions are made are too large, and entirely different weather may prevail in different portions of the same district. To say that local rains will occur on a given day in, for instance, the Ohio valley, is not altogether satisfactory to residents in different portions of the valley. To anticipate, by way of illustration of this: Suppose a storm is central over the western plains—weather generally travels in an easterly direction—the Signal Service

announcement would be local rains for the upper Mississippi valley on the morrow, and on the next day for the Ohio valley. Now, those in different portions of either district, who have some knowledge of local signs and indications, can supplement this official announcement for their district, and determine for themselves whether the coming rain is or is not likely to reach their particular locality during the day. A little practice will enable the merchant or the farmer to read between the lines of the necessarily brief and sometimes misinterpreted government report with good results.

The Signal Service system is also employed in Great Britain and among other European nations. It consists in taking careful and simultaneous observations at a great number of representative points of the pressure and temperature of the atmosphere, the direction and velocity of the wind, the degree of moisture or saturation of the air, the cloudiness, etc., at each point. In our country, these observations, made several times each day, are promptly reported by telegraph to the central office at Washington, and there projected upon a map of the country, which then shows at a glance the distribution of sunshine and cloudiness, of warm and cold, of fair and foul weather at the time, just as the geographical map shows the distribution of mountains and valleys, plains and river courses, land and water. Our present weather science dates from the time of making simultaneous observations at numerous and widely scattered places, and the use of the telegraph in transmitting the results. Without the weather map, it would not be possible to predict weather for the various geographical divisions of the country from any central point, as is now done with great success. Without a knowledge of the principles of meteorology, the established laws and generalizations, weather reports are of little value in respect to making any deductions therefrom. There is no limit to the utility of such knowledge, and it is not difficult to acquire. There is nothing mysterious attaching to it. When once leading facts are mastered and borne in mind, there is a wonderful simplicity in meteorology. There is an absorbing fascination in the constantly changing conditions, as revealed from day to day by the weather map. From the

study of this map are made the forecasts for the various geographical, or rather meteorological districts, for short durations of time. These forecasts, or "INDICATIONS," are based upon established laws of storms, as will be shown further on.

WEATHER SIGNS.

Benjamin Franklin said it took a wise man to carry an umbrella when it did not rain; any fool could carry one when it rained. If Franklin meant that his sage should depend on "signs," he must have overlooked the fact that "all signs fail in dry weather." At such times, no matter how much it *looks* or *feels* like rain, the moisture contributing to this appearance or feeling that, under other circumstances, would have been precipitated, is carried far beyond us, and umbrellas are incumbrances.

Sir George Harvey, in an article on Meteorology, wrote: "It is humiliating to those who have been most occupied in cultivating the science of meteorology, to see an agriculturist or a waterman, who has neither instruments nor theory, foretell the future changes of the weather many days before they happen, with a precision which the philosopher, aided by all the resources of science, would be unable to attain."

Strange as it seems, the faculty of weather wisdom is still generally in an inverse order to the intelligence of the possessor. The farmer, the sailor, or any one who leads an out-door life, and who keeps his eyes and ears open, and carefully notes the countenance of the sky and the successive changes in the state of the atmosphere, is most apt to be able to foretell the coming storm, or atmospheric change, from the appearances which tradition, and his own experience and observation, have taught him announce one. If, now, in addition to this experience as to his own locality, he has the advantage of some general knowledge of the subject, of seeing the weather reports, and learning the conditions prevailing elsewhere, he would seldom go astray in his weather calculations.

Many of us are weather wise through our feelings and sensations. When a storm is about forming, or is approaching, the air is saturated with moisture which is charged with

powerful negative electric tension, repelling the negative electricity of the soil, and attracting positive electricity to the surface. We are then in an electrical condition opposite to that which is natural to us. We are "under the weather." Many of us suffer from "the blues." Who knows but that many an act of suicide is attributable to the influence of the weather? Those suffering from chronic diseases feel the change. Invalids feel it. Our pet corns, with shooting pains, torment us.

"Old Betty's joints are on the rack." Heads ache, and we feel dull and drowsy. As soon as the negative tension of the storm has been diminished, by discharges or by rain, our discomfort begins to cease. Then follows bracing air, attended by evaporation and positive electricity, which clears up the weather, and restores us to our natural, active condition. This is the effect of a "high barometer," that usually follows a "low barometer," or storm wave.

The very trees and vegetation seem to feel and give "signs" of coming changes.

"The whispering grove betrays the gathering elemental strife." Who has not observed this *whispering* of the leaves—the peculiar vibrating, up-and-down motion, when there is no wind? All vegetation discharges electricity, and such discharges, when active, move the leaves, and produce a rustling sound, which the poet calls "whispering."

That "appointed signs foreshow the weather," is undeniably true; and a great many of the proverbs based upon these signs, commend themselves to our attention for their philosophical accuracy. The Bible allusion to the weather, in the words, "*When it is evening, ye say, It will be fair weather, for the sky is red; and in the morning ye say, It will be foul weather, for the sky is red,*" was simply a reference to an already existing popular proverb, founded upon common observation, the truth of which is confirmed by science. The different tints of the sky depend upon the condition of the vapor in the air. *Evening* red is an indication of fine weather on the *morrow*, because it shows the vapor in the air is not *condensed* into rain-bringing clouds. The rosy sunset is due to the red rays of the sun being bent through

the vapor of the air that is simply on the point of condensation. *Morning* red is an indication of *rain*, because it shows the upper regions of the air to be laden with vapor on the point of condensation; and, as the day advances, the additional vapor carried up by the warm, ascending currents will cause the formation of clouds, likely to result in rain.

But the Bible reference to wind, which, it is written, "*bloweth where it listeth; ye can hear the sound thereof, but can not tell whence it cometh, nor whither it goeth,*" has been found to be incorrect: for wind, as well as every other element of nature, is govered by fixed and immutable laws, and is but the effect of a cause, as we shall presently see. In those days there were neither barometers nor weather maps, and wind, or air in motion, was a mystery. In the remark, "*There is a* SOUND *of abundance of rain,*" the Prophet Elijah showed how very old is the knowledge of the fact that sound is heard more distinctly, and at greater distance, before rain. In our days of rattling railway cars and sonorous steam whistles, we have admirable guides as to the imminence of rain.

Much of the weather lore that has come to us in the form of proverbs, sayings, and signs, is founded on truth, and therefore useful and reliable. The philosophy of it is apparent. But, on the other hand, much of it has neither sense nor reason. The lower animals have a certain premonition of coming weather changes from their sensations. They become restless and uneasy before rain; and many prognostications are based upon the cries or motions of various beasts, birds, fishes, reptiles, and insects. These, however, may be taken as guides only in so far as they show that a change is already in progress, and they already feel its influence.

The following is a clever collection of

WEATHER SIGNS.

"The hollow winds begin to blow,
The clouds look black, the glass is low,
The soot falls down, the spaniels sleep,
And spiders from their cobwebs creep.
Last night the sun went pale to bed,
The moon in halos hid her head.

The walls are damp, the ditches smell,
Closed in the pink-eyed pimpernel.
Loud quack the ducks, the peacocks cry;
The distant hills are looking nigh.
How restless are the snorting swine!
The busy flies disturb the kine.
Low o'er the grass the swallow wings;
The cricket, too, how loud it sings!
Puss, on the hearth, with velvet paws,
Sits smoothing o'er her whiskered jaws.
Through the clear stream the fishes rise,
And nimbly catch the incautious flies.
The sheep were seen at early light,
Cropping the meads with eager bite.
Though June, the air is cold and chill;
The mellow blackbird's voice is still.
The glow-worms, numerous and bright,
Illumed the dewy dell last night.
At dusk the squalid toad was seen,
Hopping, crawling o'er the green.
The frog has lost his yellow vest,
And in a dingy suit is dressed.
The leech, disturbed, is newly risen,
Quite to the summit of his prison.
The whirling wind the dust obeys,
And in the rapid eddy plays.
My dog, so altered in his taste,
Quits mutton bones on grass to feast.
And, see yon rooks, how odd their flight,
They imitate the gliding kite;
Or seem precipitate to fall,
As if they felt the piercing ball.
'*T will surely rain:* I see, with sorrow,
Our jaunt must be put off to-morrow."

WEATHER KEYS.

The atmosphere which envelops our earth is the great factory in which all the meteorological phenomena occur. The ever varying PRESSURE, TEMPERATURE, and MOISTURE of the air, are the three *keys* with which to unlock the weather mystery, which ceases to be a mystery when these principal elements constituting *weather* are understood.

MOISTURE, manifesting itself in various ways, is perhaps the principal element to be considered in determining local weather changes. The air is never quite dry, and at times

it is so full of moisture that a fall of rain is almost inevitable. Increasing heat increases the capacity of the air for holding moisture. Evaporation, or the conversion of visible water into invisible vapor, is constantly going on to a greater or less extent. A simple saucer full of water exposed to the open sky, and protected from interference, will, by the more or less rapid diminution of the quantity of water through evaporation, give indications of the weather. Dryness, or fair weather, is connected with a rapid rate of evaporation, and dampness, or wet weather, with a slow or more or less suspended rate of evaporation. Any intelligent, practical observer, can get satisfactory results in local weather predictions by simply watching the clouds and the varying humidity of the air, as indicated by two common thermometers arranged as shown in *Fig.* 1, and called a HYGROMETER.*

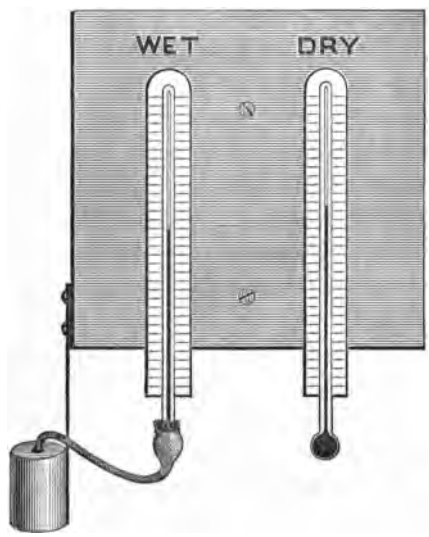


Fig. 1.—A Hygrometer.

* I take pleasure in recommending to persons desiring to procure reliable instruments at reasonable prices, either MR. FERD. WAGNER, 41 West Fifth street (*Fountain Square*), Cincinnati, O., or MR. C. G. BÖERNER, Vevay, Ind. Mr. Wagner has always on hand a complete stock of meteorological instruments, as well as mathematical and optical goods. Mr. Böerner's

The instruments should be perpendicularly secured on a piece of board about ten or twelve inches apart, and both should show the same temperature. Then cover the bulb of one ot the thermometers with a wick leading into a small covered vessel, fastened to that side of the board and at some little distance from the bulb, containing preferably rain water. The readings of that thermometer, called the "wet bulb," will usually be found to be lower than those of the other. This is due to the water absorbed by the wick rising by capillary attraction to the end of the wick over the bulb and evaporating, causing cooler air around that bulb, and thus lowering the mercury in the tube. In dry weather evaporation goes on rapidly. In damp weather evaporation is slow. When the air is thoroughly saturated with moisture, evaporation from the wick ceases, and the two thermometers read alike. That is to say, the moisture in the air, when thoroughly saturated, has the same effect upon the "dry bulb," as the water held by the wick has upon the "wet bulb." Should, for instance, the dry bulb read 60°, and the wet bulb 50°, the percentage of relative humidity would be 44 or low, as can be seen by reference to the table on page 17. By relative humidity, is meant the proportion of vapor in the air at any time compared with what the air could contain at that time if thoroughly saturated. Saturation being expressed by 100, the above, it will be seen, would be low, less than one half, indicating dry weather. On the other hand, should the dry bulb read 60°, and the wet bulb 58°, the percentage of humidity would be 88, or high. Should both read alike, care always being taken that the vessel is kept supplied with water and the wicking clean, the percentage of humidity would be 100—that is, the air would be thoroughly saturated with moisture. The greater the difference in the readings, the drier the air, and the less chance for rain.

A table for finding the relative humidity at any moment, by simple inspection, is given. Note the difference between the readings, and find the percentage of humidity at the

is a long established house of the highest reputation. Correspondence with, or a personal visit to either, may be of advantage to the intending purchaser of meteorological instruments.

intersection of the line after the *wet bulb* reading and the column under the *amount of difference.*

RELATIVE HUMIDITY (PER CENT OF SATURATION).*

DIFFERENCE BETWEEN WET AND DRY BULBS.

WET-BULB THERMOMETER.	0°	.5°	1°	1.5°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°	25°
Zero.	100	85.0	70.7	57.0	43.8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1°	100	85.6	71.8	58.6	46.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2	100	86.2	73.0	60.2	48.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
3	100	86.7	74.0	61.8	50.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
4	100	87.2	75.0	63.3	52.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
5	100	87.7	76.0	64.7	53.8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
6	100	88.2	76.9	66.0	55.3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
7	100	88.6	77.7	67.1	56.8	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
8	100	89.0	78.4	68.2	58.2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
9	100	89.4	79.1	69.2	59.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
10	100	89.5	79	70.0	61	44	28	13	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
15	100	91.5	83	75.0	67	52	39	27	15	5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
20	100	92.5	85	78.5	72	60	48	38	28	19	11	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
25	100	94.0	88	82.5	77	67	59	48	41	32	26	18	10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
30	100	94.5	89	84.0	79	69	61	52	45	37	30	26	18	11	6	...	...	...	...	...	...	...	...	...	...	...	...	...
35	100	95.0	90	85.0	80	71	63	56	48	42	35	30	24	19	14	10	6	...	...	...	...	...	...	...	...	...	...	...
40	100	95.5	91	87.0	83	75	67	60	54	48	42	37	32	27	22	19	14	12	...	...	...	...	...	...	...	...	...	...
45	100	96.0	92	88.5	85	77	71	64	59	53	48	43	38	34	30	26	33	19	16	13	10	...	...	...	...	...	...	...
50	100	96.5	93	89.5	86	79	73	68	62	57	53	48	44	40	36	33	29	26	23	20	18	15	13	11	...	...	...	...
55	100	96.5	93	90.0	87	81	76	70	66	61	57	52	48	45	41	38	35	32	29	26	24	20	19	17	15	13	11	9
60	100	97.0	94	91.0	88	83	78	73	68	64	60	56	52	49	45	42	39	36	34	31	29	26	24	22	20	18	17	15
65	100	97.0	94	92.0	90	84	79	75	71	67	63	59	56	52	49	46	43	40	38	35	33	31	29	27	25	23	21	20
70	100	97.5	95	92.5	90	85	81	76	72	69	65	61	58	55	52	49	46	44	41	40	37	35	32	31	29	27	26	24
75	100	97.5	95	92.5	90	86	82	78	74	70	67	64	61	58	55	52	49	47	45	42	40	38	36	34	32	30	29	27
80	100	97.5	95	93.0	91	87	83	79	75	72	69	66	63	60	57	54	52	49	47	45	43	41	39	37	35	34	32	30
85	100	98.0	96	93.5	91	88	84	80	76	73	70	67	64	62	59	56	54	52	50	47	45	43	41	40	38	36	35	33
90	100	98.0	96	94.0	92	88	85	81	78	75	72	69	66	63	61	58	56	54	52	49	47	46	44	42	40	39	37	36
95	100	98.0	96	94.0	92	89	85	82	79	76	73	70	68	65	62	60	58	56	53	51	49	48	46	44	42	41	39	38
100	100	98.0	96	94.5	93	89	86	83	80	77	74	71	69	66	64	62	59	57	55	53	51	50	48	46	44	43	41	40

But a knowledge of the mere percentage of existing moisture is not of so much practical importance to the farmer or others, whose business pursuits depend largely upon weather conditions, as the fact whether dampness is increasing and rain therefore probable, or whether the air is drying and fair weather likely to ensue. These facts are admirably indicated by the little instrument above described. The approaching or separating thermometers, taken in connection with the wind direction and local signs, together with the information furnished by the weather reports, should enable any one to satisfy himself as to his probable weather for at least a day or two in advance.

THE DEW POINT.

The air deposits a portion of its vapor on all bodies that are colder than itself, and the temperature at which such deposit of moisture is made is called the *Dew Point.* The *Dew Point* may at all times be found by calculation with a set of factors.

The rule is: *Multiply the factor opposite the reading of the dry bulb into the difference of the dry and wet bulb thermometers, the reading of the dry bulb thermometer, less the product found, will be the* DEW POINT.

TABLE OF FACTORS FOR COMPUTING THE DUE POINT.

Dry Bulb.	Factor.	Dry Bulb.	Factor.	Dry Bulb.	Factor.
20°	8.1	29°	4.6	38°	2.4
21	7.9	30	4.2	39° to 41°	2.3
22	7.6	31	3.7	42 to 45	2.2
23	7.3	32	3.3	46 to 50	2.1
24	6.9	33	3.0	51 to 56	2.0
25	6.5	34	2.8	57 to 64	1.9
26	6.1	35	2.6	65 to 73	1.8
27	5.6	36	2.5	74 to 86	1.7
28	5.1	37	2.4	87 to 90	1.6

EXAMPLE.

Suppose the dry bulb reads		65°
Wet bulb		59°
The difference		6°
Factor (from the table, 65°)		1.8
Product		10.8
Dry bulb reading	65°	
Less product	10.8	
DEW POINT	54.2°	

Suppose the dry bulb reads 60.5°, and the wet bulb 60°. This would show that the air is very highly saturated, and, by reference to the Relative Humidity Table, it would be found that the percentage of humidity was 97. Rain could be expected, because the air contained nearly as much moisture as it was capable of sustaining. Computing the dew point, or temperature required to condense the vapor, in this case we find it to be 59.5°.

$$(60.5^\circ - 60 = .5^\circ \times 1.9 = .95\,;\ 60.5 - .95 = 59.5^\circ +).$$

That is to say, the temperature of the air in this case has to sink less than one degree, in order to produce rain.

As a guide to the probability of rain, the application of this method becomes interesting, and is generally found reliable.

If the mercury in both bulbs rises as the day advances, rain is likely, since the temperature of the air will naturally fall with the decline of the sun. In sultry weather clouds and other "signs" of rain may mislead us, but if we look at the evening sky and see there the fair weather red, as well as consult our hygrometer, and find there a considerable difference in the readings, we need not apprehend rain on the morrow. A rapid increase in the difference between the two thermometers in the morning foretells a fine day. An increasing difference between the temperature of the air and the temperature of the dew point, accompanied by a fall of the latter, is a certain sign of fair weather. But diminished heat and rising dew point foreshow rain. Fog and mist, resulting from the difference of temperature between the surface of the earth and the overlying strata of air *ascending*, is a sign of rain, as so much more vapor is being added to the amount already contained in the air. When the upper regions of the air are saturated with vapor, as indicated by *halos* around the sun or moon, it is a well-known sign of rain—the larger the halo the nearer the rain. Air saturated with vapor is much more transparent than dry air, and unusual clearness or transparency is therefore a sign of rain. Under such conditions distant objects are seen with greater distinctness, which is an indication of rain. *Lights* appear brighter and nearer before rain. The refracting power of

the air becomes greater through the increasing aqueous vapor in it, and distant objects, especially over water, *loom*, or have an apparently increased elevation. On the other hand, when there is a deficiency of this vapor, and there are commingling strata of air of different temperatures, there is *haziness* indicating dry weather.

CLOUDS are simply aggregations of the particles of vapor in the air assuming well-defined forms and peculiarities. They appear and disappear, and assume their various shapes, according to the state of the atmosphere in respect to moisture, temperature, and movement. With their various forms all are acquainted by observation. Being merely packed particles of moisture, they are subject to temperature and wind, as the latter are governed by pressure, as we shall see further along. *Cirrus* clouds resemble locks of hair or feathers with parallel diverging fibers. They are the highest and least dense. They sometimes cover the sky as a mere transparent haze, and sometimes form themselves into collections of parallel threads, assuming an infinite variety of wavy fibrous shapes. They consist of icy spiculæ or the frozen vapor of the upper regions. They are the first to make their appearance after a period of fair weather, and are the forerunners of coming foul weather. When the ends of these "cats' tails" curl and point *upward*, rain can be expected; when *downward*, fine weather. In the former case, a warm ascending current is attended by the decomposition of vapor preceding rain; in the latter, a cool descending current produces evaporation, and, consequently, fair weather. When these clouds sink and become denser, the result of increasing moisture in the upper air, they assume the appearance somewhat of carded cotton, and this change foretells rain.

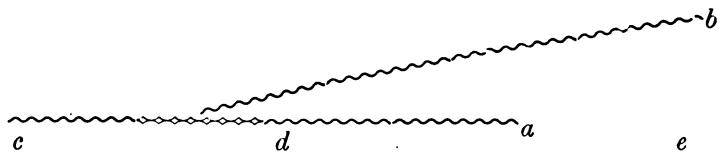
CUMULUS clouds are produced by warm currents of air ascending and expanding. They are associated with fine, warm summer weather. So long as these preserve their regularity and float along in their accustomed serenity, the existing fair weather is not likely to be interrupted. The volume of these sometimes majestic clouds is greater on warm, moist days, than when the weather is cold and dry, for evident reasons. When the edges or outlines of these clouds are sharp and

well defined, it shows a dry atmosphere, and therefore presages fair weather. As all atmospheric disturbances are due to a disturbed equilibrium of the air, it is a sign of fair, normal weather, when the under surface of these massive and majestic clouds is uniform and level, showing that the equilibrium of the air strata upon which they float is unbroken.

STRATUS is the extended, uninterrupted *sheet* of cloudiness that prevails in threatening, dismal, rainy weather. The hurrying *scud* cloud is a reliable sign of rain. When small clouds disappear, there will be no rain that day. If they increase in size, and unite, falling weather is at hand. The reason is plain. When the air is charged with electricity clouds are attracted to each other, and combinations are formed which result in showers, or heavy rains, according to the intensity of the conditions. When the electricity is passing off, or is diffused, clouds break up, and are dissolved. A "mackerel sky," which is a combination of *cirrus* and *cumulus* clouds, indicates fair weather for the day; but presages rain within a day or two after. The French have a proverb, "A dappled sky and a painted woman don't last long."

To produce rain, there must be a combination, in some form, of the upper and lower cloud formation—the icy vapor uniting with the vesicular. The *halo* around the moon shows the saturation of the upper regions of the sky—the descent of the icy *cirrus*. The larger and more complete, or better defined, the circle, the greater the degree of saturation. A warm south wind now bringing up the stately *cumulus*, rain results from the union of these two principal types of cloud, on the same principle that pouring ice in a glass tumbler, on a warm, moist summer day, will cause a deposit of water on the outside of the tumbler. The temperature to which the glass had been reduced by the ice at the moment the vapor of the surrounding air began to condense on its sides, is the *dew point*. In wide spread rain storms, there are two or more layers or strata of clouds, the upper stretching out in advance of the lower, but merging into it over the region where rain is falling most copiously.

Suppose our locality is *e*. The upper layer *b* has reached us, and we are beginning to see the approaching lower layer *a*. We can expect rain. If, now, an extended rain storm having set in, our locality is *d*, and there be breaks in the lower layer, we can not see the sky through them, because of the intervening upper layer. Our heaviest rain is probably yet to come. But if our locality were *c*, and breaks occurred in the clouds, we would be able to see the blue sky, the upper layer having passed beyond us; and we could expect an early end of the rain, and the return of fair weather. The character of the clouds, their combinations and movements, are important elements in forecasting local weather. They are the effects of movements of aerial currents, and show, by their kind and changes, the pressure, temperature, and moisture at higher altitudes; and, by their movements, the prevailing currents of air, indicating whether the weather is likely to be warm or cold. If properly interpreted, clouds are sure indices of coming weather.



Rain is the vapor of the air condensed and precipitated. This condensation is the result of a cooling of the air below the temperature of the dew point. This cooling takes place through radiation, the mingling of warm and cold masses of air, the opposition of winds of different temperatures, or any cause that produces condensation, either gradual or sudden. When variable winds prevail, light rains may generally be looked for. The amount of water received by the earth, from the clouds, is interesting and surprising. This amount can be very accurately ascertained by the rain guage, *Fig.* 2. A rain guage may consist of a funnel-shaped collector and a cylinder, made of stout tin; the former securely fitting into the latter, as shown in the cut. It should be securely placed, with an exposure as clear as possible, and with the top of the funnel on a level. If the top of the funnel is ten inches in diameter, and the diameter of the cylinder about 3.16 inches,

or the square root of 10 inches, the proportion between the cylinder and funnel will be as one is to ten; and ten inches of rain collected in the cylinder would equal one inch in the

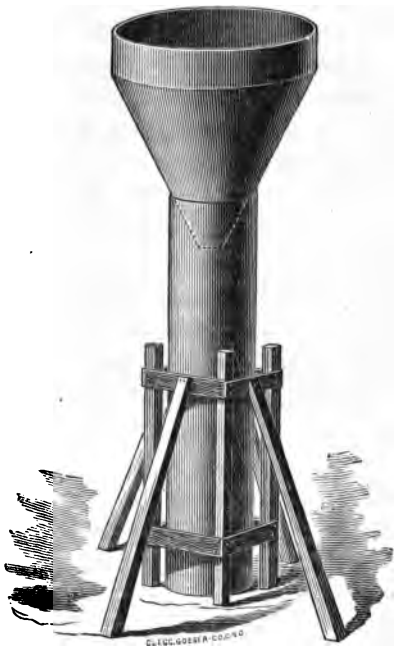


Fig. 2.—Rain Gauge.

funnel, or one inch actual rain-fall. Fifteen inches in the cylinder would be one inch and a half actual rain-fall. One inch in the cylinder would equal *one-tenth of an inch* rain-fall. The length of the cylinder is immaterial; the longer the better, as it lessens the chance of overflow in case of specially heavy rains. The measuring rod—a thin, narrow strip of wood of the length of the cylinder—is graduated in inches and tenths of inches; and, when making an observation, the funnel is removed, the rod inserted in the cylinder, and the depth of water accurately noted; after which the water is emptied, and the funnel replaced. Should the rod indicate a depth of twelve inches of water in the cylinder, the actual rain-fall would be one inch and two-tenths. It is an easy matter to calculate how many *gallons* of water fell during

any rain storm, or any season, upon any given area of surface. As before stated, the amount will be found to be surprising.

Frosts should not take the farmer or the horticulturist by surprise. The probability of their occurrence can be known with almost as much certainty as the arrival of an express train. For practical use, one of the most important meteorological instruments is the *hygrometer* (page 15), by means of which can be ascertained at any time the *dew point*, and the approach of low temperature, or of frost, thus foreseen and provided against. If on a fair day, toward evening, the dry bulb, which would also be the temperature of the air, indicated 50° and the wet bulb 38°, the dew point at the time would be about 25°, and frost could of course be expected. If, on the other hand, the dry bulb were 50° and the wet bulb 48°, the dew point then would be about 46°, and no frost need be feared under the circumstances. The rule and table of factors for computing the dew point is given on page 18. The temperature of the air need not necessarily sink to 32° to produce frost, since plants and other good radiating bodies may become cooled by radiation considerably below the temperature of the surrounding air, and a heavy frost may occur when a thermometer at some elevation above the surface indicates only 36° to 40°. A light frost may occur when the same thermometer indicates as high as 45°, or even 50°, of temperature. The formation of frost depends upon the dew point. Dew and frost, like rain and snow, are formed under the same circumstances, excepting the difference in temperature. Severe frosts, in their season, are found in the cooler, evaporating air attending the advance of areas of high barometer, and the approach of such areas may always be known by an intelligent reading of the weather reports.

Wind is simply air in motion. Capricious as wind seems to be, it is nevertheless subject to definite laws. The *direction* of the wind is determined by the vane, and its *velocity* by an instrument called an *anemometer*. The indications of the latter are expressed in pounds of pressure per square foot of exposed surface. The pressure (in pounds per square foot)

of wind velocities of from one to ten miles per hour is as follows:

Miles per hour.	Pressure per sq. ft.	Miles per hour.	Pressure per sq. ft.
1	.01 lbs.	6	.18 lbs.
2	.02	7	.24
3	.04	8	.32
4	.08	9	.40
5	.12	10	.50

The rule is, that *the force of the wind varies as the square of its velocity.* The force of a wind blowing at the rate of twelve miles per hour would, therefore, be just four times as great as that of a wind blowing six miles per hour, or .72 of a pound per square foot. The calculation can be carried on indefinitely. A wind blowing 24 miles per hour would exert a pressure four times as great as one blowing 12 miles per hour, or 2.88 lbs. Wind blowing 48 miles per hour would exert a pressure four times as great as one of 24 miles, or 11.52 lbs. 96 miles per hour, which would be a tremendous hurricane, would exert a pressure four times as great as 48 miles, or 46.02 pounds on every opposing *square foot* of surface. The Signal Service designates winds of 1 and 2 miles per hour as *light;* 3 to 5 miles, *gentle;* 6 to 15 miles, *fresh;* 16 to 25 miles, *brisk;* 26 to 40 miles, *high;* 41 to 60 miles, *gale;* 61 to 80 miles, *storm;* 81 to 150 miles, *hurricane.* The force of a wind blowing at the rate of 150 miles per hour would be equal to a pressure of 112.5 pounds per square foot.

The causes of winds are:

1. *Unequal atmospheric pressure.* This creates motion in the air. With uniform pressure over any extent of country, there is very little, if any, motion or wind. The wind blows from regions where the pressure is greatest, to regions where it is least. Storms are areas of lowest pressure; therefore, the wind blows toward storms from all directions.

2. *Unequal specific gravity of the air.* This results from differences of temperature and humidity. Denser or colder air will flow toward regions where lighter or warmer air prevails, underrunning and displacing the latter. A storm is a

concentration of heat, causing the air to expand, become lighter, and ascend. Cooler or colder air, according to the season, therefore, flows into the storm region to re-establish an equilibrium, and hence the change of temperature after a storm preceded by warm weather. The specific gravity of vapor is much less than that of dry air, and air, therefore, flows from dry to moist localities.

The rotation of the earth has a relative effect upon the motion of the air. The velocity of the earth's rotation around its own axis every twenty-four hours is different in different parallels of latitude. At the equator the velocity eastward is 1036 miles per hour; in latitude 15°, 1000 miles; 30°, 897 miles; 45°, 732 miles; 60°, 518 miles; 75°, 268 miles; and at either pole, nothing. There being being but two primary motions of air, north and south—the other relative motions, due to the greater or less velocity of rotation of different parallels of latitude, will be readily understood. The *temperature* of the wind depends, of course, upon the quarter from which it blows and the distance it traverses from such quarter.

HIGH AND LOW BAROMETER.

Each particle of the elastic air exerts a pressure upon those beneath it, and the weight or pressure of the entire mass upon the surface of the earth is recorded by the barometer. Atmospheric pressure varies as the motion, depth, density, moisture, and temperature of the atmosphere varies. Increasing or higher pressure means a flow of deeper, dryer, and cooler air over a given region, as shown by the *rising* mercury in the barometer tube. Decreasing or lower pressure means a diminishing weight of the air, because it is then lighter, warmer, moister, and ascensive, and the mercury in the barometer tube sinks correspondingly. The term "area of *high* barometer," means a region of country over which there is an excess of air. The term "area of *low* barometer," means a region of country over which there is a deficiency of air. The former is, as a rule, attended by fair and the latter by foul weather. *Storms* are areas of *low* barometer, and as they approach our locality our barometer falls, that is, the mercury in the tube *sinks*, by reason of the influence

of the coming storm, which draws the air toward its center, where it ascends. The fall of the mercury is according to the severity of the storm. If we happen to be in the path of the storm, our barometer will be lowest when the storm center passes over us. As the storm center passes by us, the barometer begins to rise, because there is a mass of air rushing over the locality after the depression or storm center, on the same principle that water seeks a level. Central areas of storms pursue paths across our country approximately shown in Fig. 3. If our locality is A (the Ohio valley), we are within influential distance of all storm centers taking the tracks, K L, H I, D E, and sometimes F G, and B C. B C, and D E, are West India cyclones, the latter out of their regular course.

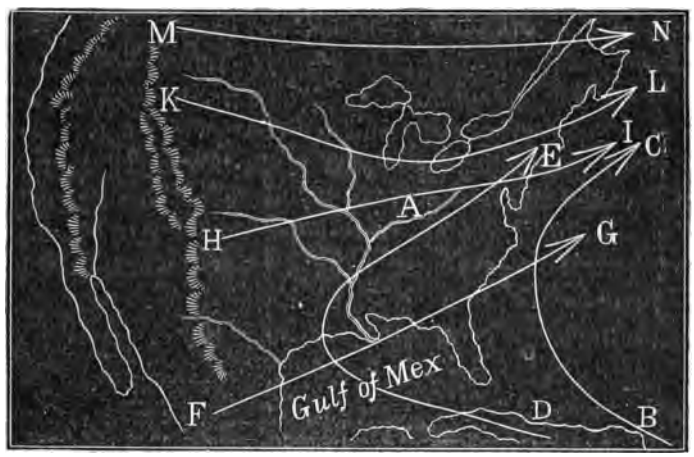


Fig. 3.—Storm Tracks.

When the barometer is reported lowest in a certain region, it means that there is a storm central there. When it is reported highest in a certain region, it means that that is the central region of the fair weather area. When the construction of the barometer—the difference between dry, cool, bracing and heavy, and moist, warm, enervating and light air, as well as the fact that the atmosphere is forever seeking an equilibrium—that areas of low and areas of high barometer are constantly chasing and changing their relations to each other—is understood, this matter will be clear. It is a

common mistake to say that the air is *heavy* in damp, wet weather, and *light* in fair, normal weather. The opposite is the case. Some of the effects of low barometer, or stormy weather, upon man and beast, have already been alluded to. When HIGH takes the place of LOW, a grateful change is experienced, and the duration of the new condition can be approximately anticipated by reference to, and a study of, the weather reports. A high and steady barometer indicates, as a rule, dry, clear, fine weather. A low and fluctuating barometer indicates cloudy, windy, or wet weather. Changeable weather is indicated by a quick rise, followed by a quick fall, in the barometer, or the reverse. Fair, still weather is the normal condition of the atmosphere, just as health is the normal condition of living beings. Changes from this normal condition of the atmosphere are the results of forming, approaching, or passing disturbances. There is no uniformity or regularity in the intervals between these changes of conditions. The beginning, or first appearance, of a change can always be detected in the weather reports. The elements to be considered in any locality, in determining the immediate future of the weather, are atmospheric pressure, temperature, wind, moisture, the appearance of the sky, and (as announced by the telegraphic reports) the fact of precipitation elsewhere, whether in the form of rain or snow.

Areas of HIGH BAROMETER, and areas of LOW BAROMETER, are attended by their own system of winds circulating around them, toward and into the *Low*, and from and out of the *High*. PLATE I. illustrates this wind circulation, the long arrows showing the usual direction of movement of the areas themselves. The direction of the wind is one of the main elements to be considered in weather predictions; and it can be known with reasonable certainty what winds will prevail, if it is known where the barometer reads highest, and where lowest, and this information the weather reports usually give. The rule is: "*Stand with your left hand toward the region where the barometer is lowest, and your right hand toward that where it is highest, and you will have your back to the direction from which the wind will blow during the day.*" Or, knowing the region of lowest pressure, and we stand *facing*

it, our wind will blow from some point on our left to some point on our right. Not knowing the region of lowest pressure, if we stand *facing the wind*, the storm center will be on our right. An inspection of the area marked "Low" on *Plate I.* will clearly demonstrate this. Stand anywhere around the area facing the *center*, and the wind will be found to blow on your right side. Stand anywhere around the area of "Low," *facing the wind*, and the storm center (*Low*) will be on your right. The opposite holds good in the case of HIGH. The former is a *cyclonic*, and the latter an *anti-cyclonic* system of winds. The lower clouds indicate the true direction of the wind better than the vane, since local surface winds may be diverted from the general direction by the topography of the earth or other obstructions. Air has primarily but two motions, northward and southward. But common observation shows us that the wind blows in every possible direction; and we have seen that there are two entirely opposite *systems* of circulation of air around areas of high and low barometer. The wind does not usually blow *directly* into a region of low, or out of a region of high, barometer; but is, in both cases, deflected toward the right; and this deflection is increased according to the size or extent of the area, whether of low or high pressure, around which the wind is blowing. Professor Ferrel has demonstrated, that this deflection to the right is a mathematical necessity arising from the influence of the earth's daily rotation, causing every thing moving on its surface to deflect to the right in the northern hemisphere, and to the left in the southern hemisphere. The air, then, has a sinuous, spiral motion inward, toward the center of a region of low pressure, and at the center it flows upward from the surface. The friction of the earth's surface may retard this deflected or tangential motion of the air, and, in storms of great energy, the wind may be found to blow more nearly directly toward the center of the disturbance.

The wind, then, in any locality, may be expected to be—

Easterly, when High is in the north, or Low in the south.

Southerly, when High is in the east, or Low in the west.

Westerly, when High is in the south, or Low in the north.

Northerly, when High is in the west, or Low in the east.

An inspection of *Plate I.* will make the above quite clear; and a daily application of the rule will verify it in nearly every instance.

ISOBARS.—By drawing lines upon a weather chart, or map, connecting the places where the barometer readings indicate equal pressure, we are enabled to definitely locate the position and extent of areas of low and high barometer, and, with some practice and experience, to determine about when such areas, with their attendant weather, will reach and overlie our own locality. Such lines are called *isobars.* To locate an area of *low* barometer, seek out the places where the barometer reads the lowest, and encircle them, as far as possible, by an isobar. Take, for example, a report projected on the CINCINNATI COMMERCIAL GAZETTE'S weather map (Fig. 4). At the time of that report, we find that, at Chicago, the barometer reads 29.77 inches; at Indianapolis, 29.74 inches, and at Louisville, 29.78 inches. Now, trace a line representing approximately 29.80, from near Toledo to west of Cincinnati, east of Louisville, thence around Louisville, on the south, and curving north-westward through Vincennes; thence slightly west of Chicago, and on, north-eastward, over Lake Michigan. You have here inclosed the region of lowest pressure on the map, which, in this case, however, is not the storm center, but the southern *extension*, or southern portion of the oval storm area, whose center is over the lake regions. Then trace a line for one-tenth of an inch higher pressure, or 29.90 inches, beginning west of Pittsburg; thence south-westwardly, keeping slightly north of Nashville and Memphis, passing *through* Little Rock; thence around Fort Gibson, and again north-eastward, passing slightly east of Keokuk and Davenport, describing a curve around the west of La Crosse, and running the line north-eastward again, beyond the limits of the map. This line incloses the usual barometric trough accompanying a storm movement, and generally lagging behind in the eastward movement of the storm.

If the map included and reports were had from British America, the northern portion of this storm area could be inclosed in a manner similar to that here shown. At Chattanooga and Vicksburg, it will be observed, the barometer

COMMERCIAL GAZETTE WEATHER MAP.

'rom Observations Made by the Signal Service, U. S. A., at 10:30 P.M.. Washington Mean Time.

The following observations are taken at the same moment of time at all the stations named.

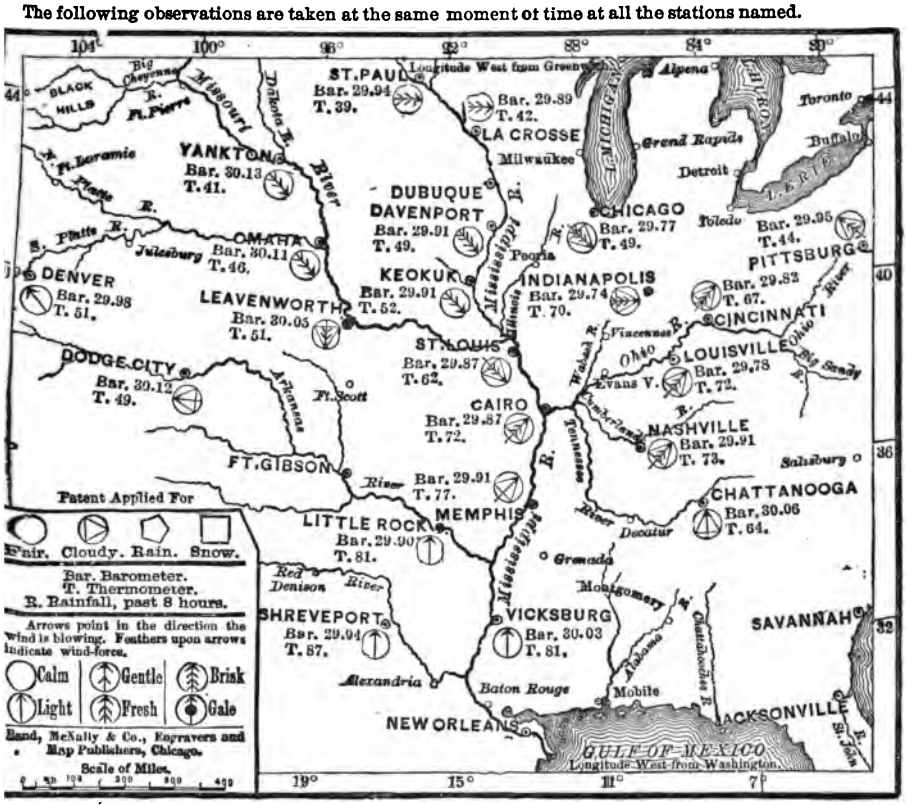


Fig. 4.

reads over 30 inches. A line for 30 inches of pressure, drawn through Salisbury, Decatur, Grenada, and Alexandria, leaving Chattanooga and Vicksburg east of that line, will show a portion of the western edge of an area of *high* barometer that preceded the storm movement above partly inclosed. High and Low, like waves of a tempest tossed ocean, follow each other across the country, their paths varying over higher or lower latitudes, according to the season of the year. On the map (Fig. 4), the increasing high barometer, with its colder, northerly and north-westerly winds and clearing weather, is at once observed in the Missouri valley. Fig. 5, perhaps, better illustrates the foregoing, by showing the isobaric lines to be traced on the weather map (Fig. 4).

It is the study of these areas of high and low barometer, as they succeed each other in their transit across the country, that is of importance. Predictions for the various geographical districts are based upon the result of such study. Predicting the approach of a storm (*low barometer*), or a period of fair weather (high barometer) after a storm, is in this way comparatively easy. The *duration* of either condition depends upon its extent and rapidity of movement. The things to be considered are the position or location of the coming condition, its rate of progress, its probable path, and whether or not and *when* it will reach our own locality. Local signs will generally help to settle the last point.

In the lower corner of *Plate I* is given a profile view of the atmosphere assumed to be overlying the country, as shown on the plate. The *isobars*, or lines of equal pressure, encircling the areas of High and Low shown in the face view, are represented in the profile by the arrows. It may be well to say, that all barometric readings, no matter where taken, are corrected, not only for temperature and instrumental error, but for elevation above sea level, so that each barometer is made to read as though it were at the level of the sea. This is done for purposes of comparison and scientific study. The rise and fall of the mercury in isolated instruments, allowance being made for the effect of temperature, is sufficient for practical purposes. The correction for temperature is as

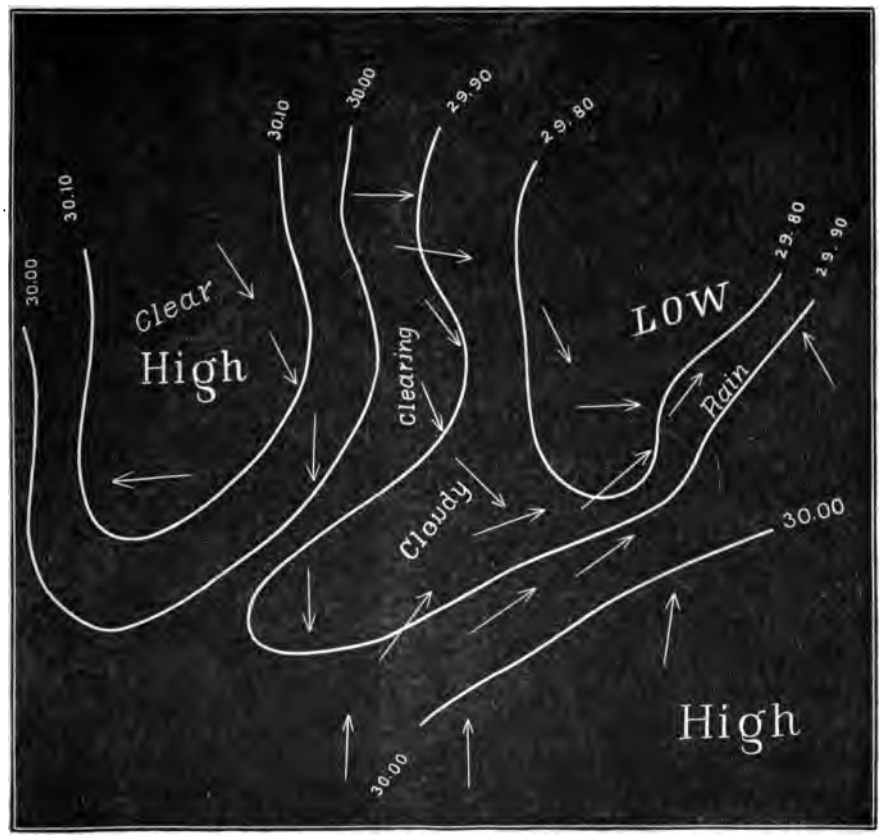

30.00
30.10
30.10
30.00
29.90
29.80
29.80
29.90
Clear
High
Clearing
LOW
Rain
Cloudy
30.00
High
30.00

Fig. 5.

follows: If the thermometer attached to the barometer indicates 20°, *add* .02 of an inch to the reading of the latter

For	30°	no correction is required.			
For	40°	*subtract*	.03	of an	inch.
For	50°	"	.06	"	"
For	60°	"	.08	"	"
For	70°	"	.11	"	"
For	80°	"	.13	"	"
For	90°	"	.16	"	"
For	100°	"	.18	"	"

That is to say, if your barometer should read, say 30.00 inches, and the thermometer indicated 70°, about one-tenth of an inch of the height of the mercury in the barometer tube would be due to the expansion of the mercury by heat.

Normal atmospheric pressure at sea level sustains a column of mercury in the barometer tube at a height of about thirty inches. If the air over any extent of territory were in a state of equilibrium, and the pressure, therefore, normal, or regular, the dotted line *a* (*Plate* 1) would represent its upper limit, and there would be very little difference in the barometers. Now, when, in a general fair weather state or condition of the atmosphere, the process of the formation of a center of disturbance begins, say at *m*, the moist, warm, light air in that region, *wherever it may be*, ascends, its moisture is condensed in the form of clouds, the ascending current continuing into the higher and colder strata of air, curves and descends as colder, drier, heavier air, striking, say at *n*, *wherever that may be*, and where there will then be a *piling up* of dry, heavy air above the normal line, in proportion to the depression that is being formed by the ascensive movement at *m* below the normal line. This accumulation of dry cold air from the upper regions then moves eastward, usually south of east, with an anti-cyclonic circulation of the air around its center, underrunning as a northerly wind, and displacing the warm southerly current that had prevailed, filling up the deficiency of air caused by the storm or low barometer preceding it, and restoring the normal condition of the atmosphere. See "*High*," *Plate* 1. To such *downward* movements of the air are due the unseasonably cool spells, the frosts, cold

waves, and severe "blizzards." These occur only in connection with an approaching high barometer, and are succeeded by a period of fair weather. The greater the depression, therefore, at *m*, the higher the elevation at *n*. This is respectively a *high and low barometer;* that is, a greater or less pressure of the air upon the earth, in consequence of the descensive movement of cold and heavy air on the one hand, and the ascensive movement of warm and light air on the other.

STORMS.

Treating of storms and their causes, Professor Loomis says: "Storms are caused by a strong and extensive upward motion of the air, by which means its vapor is condensed by the cold of elevation. The atmosphere receives heat from the sun, and it loses heat by radiation. Only about one-fourth of the rays of the sun are absorbed in passing vertically through the atmosphere. The remaining three-fourths are absorbed by the earth's surface, by which means its temperature is raised, and heat is thence communicated to the air which rests upon the earth. The atmosphere thus receives its heat chiefly at the bottom, and, in consequence of radiation, loses it most rapidly at the top. Since the density of the air is diminished by an increase of heat, the atmosphere is in a state of unstable equilibrium, and the lower strata tend continually to rise and take the place of the upper. Such ascending currents are formed on every tranquil day. As the air ascends, it comes under diminished pressure and expands; and, as it expands, it cools at the rate of about 38 degrees for two miles of ascent. This ascending air carries with it the vapor which it contained at the earth's surface, and, if it rises high enough, the cold produced by expansion will condense a portion of this vapor into cloud. The height to which the air must ascend before it will become cold enough to form cloud, depends upon the difference between the dew point and the temperature of the air. If the dew point be ten degrees below the temperature of the air, cloud will begin to form when the ascending current has risen about 1500 feet."

After a period of fair weather, whose duration depends upon the dimensions and rate of movement of the area of high barometer causing it, the first indications of a storm are generally to be looked for in the western semicircle. These indications are condensation in the form of long threads of cirrus cloud formation, the ordinary cloud bank at night-fall, or the extensive and general condensation in which is formed the circle around the sun or moon. The formation of a storm center, or "area of low barometer," is due to moist, warm, and light air, having an ascensive motion. This moist rising air ascends into the upper regions, where the temperature is low, and, passing the dew point, its moisture is condensed and assumes the form of clouds; and the pressure of the air upon the barometer, or the surface of the earth, wherever this operation may be going on, is gradually lessened, and the mercury in the barometer tube sinks. Or, the warm, light, vaporized air may move high over the land, frequently over strata of dry cool air, in great volume, from the central meteorological zone, gradually sinking down and forming the germs of barometric fields of low pressure, which spread and develop into extensive storm areas. It is in such fields that the heat of the sun is concentrated and storm centers originated. The earth absorbing electricity from the air, electric disturbances of more or less violence, according to the intensity of the condition, are experienced. The absorbtion or withdrawal of electricity from the vaporized air produces sudden condensation, excessive precipitation, and change of temperature. Wherever a storm is forming or approaching, the surface air within influential distance is attracted toward it. This movement begins first nearest the center of disturbance, each separate and individual particle of air being in turn attracted and set in motion, until the whole mass flows toward the storm center from all directions. Thus, if a storm is central in the Mississippi valley, the winds in the Ohio valley will be easterly, while in the eastern states they may still be dominated by another system. As the storm progresses eastward and becomes central in the Ohio valley, the winds in the eastern states will come under its influence and shift to easterly. When the storm has passed, a north-to-

west wind is felt, and this follows up the disturbance, filling up the atmospheric depression and restoring normal weather. Storm areas are generally in the form of elongated ellipses, or trough-like, much greater in length than in breadth. The shifting of the wind to the clearing-up quarter during the passage of a storm, whether through the north or the south points, will indicate to the observer whether the center of the disturbance is passing by on the south or north of his locality. If the wind sets in from the westward, having shifted through the *north* point, the depression is passing eastward, *south* of the observer; if through the *south* point, *north* of the observer.

An ordinary storm's path is generally in an eastward or north-eastward direction. The storm area extends from north to south, has more or less of an oval shape, moves eastward side foremost, its northern portion moving faster than the southern. Its diameter from north to south is of great and sometimes unknown length, while from east to west it is comparatively small. American storms are of a rotary character; they are progressive whirlwinds, moving forward in the line of an increasing spiral, and revolving from east to west in the northern, and from west to east in the southern, hemisphere. An area of low barometer, wherever it may exist, is the place where opposing currents meet. The larger this area the longer the storm, and the more extensive the rain area. The rain area is under the slope of one current over the other. The size of areas of low barometer varies from a few square miles, as in local storms and tornadoes, to hundreds of miles square, as in extensive cyclones. The heaviest gales attend the most crowded isobars, or lines of equal pressure. These can always be traced on the weather map, as shown on page 31, and illustrated in *Fig.* 5, and the approach of strong winds be anticipated. In severe storms, the wind is found to blow nearly toward the center of the disturbance. The more violent winds usually follow in the rear of an advancing storm; those that precede the storm are apt to be most dangerous, by reason of being in the area of rain, fog, etc. The wind velocity is calculated from the relative pressures surrounding the central depres-

sion. If the central depression is considerably lower than surrounding pressures, it is evident that there will be a violent rush of air into this depression. If a storm center were moving over a given place, and the atmospheric pressure there were unusually low, while at points one hundred and seventy miles distant the barometer read one inch higher, the wind velocity would be great enough to demolish houses and damage shipping. Cases of hurricanes, tornadoes, etc., are instances of these steep slopes or gradients. The steeper the gradient, that is to say, the nearer together the isobars are found to lie, the more dangerous the wind. In winter these slopes are more gradual, as the light, moist, warm, ascensive current climbs far over the other. In summer they are more steep, as the cold downward current, from its weight, banks up against the warm one.

Warmer weather is associated with a falling barometer, if the depression that induces the fall is to the west or north of your locality. As before stated, the air flows from regions of high to regions of low barometer. The Weather Report always announces where the barometer stands lowest. If the barometer is reported highest in the south and lowest in the north, your weather will be warm, but not as warm as it would be if there were no elevation of barometer in the south, because then the southerly air will not have traveled far. An excessively hot, dry summer, like that of 1881, is caused by the tracks of storms, or areas of low barometer, being invariably far to the north. Lows moving along extreme northern latitudes, as shown in *Fig.* 3, attract southerly air toward them, and the succeedings HIGHS remain too far north to materially affect the weather in the interior of our country. The result is a high degree of temperature, and possibly serious drouths, since the moisture is carried over and beyond us without meeting opposing currents to condense and precipitate it in the form of frequently much needed rain. In that case, we say: "All signs fail in dry weather."

TORNADOES.

The telegraph and the newspapers tell us of the effects of tornadoes; and the frequency of these recitals is probably

due to the increasing facilities for gathering information, rather than the more frequent occurrence of tornadoes now than formerly. They are most frequent and severe between the 35th and 45th parallels of latitude, and between the Allegheny Mountains and Kansas and Nebraska, and they are of more common occurrence in the United States than in Europe. Theoretical meteorologists tell us that the tornado is a *column*, and the cyclone an extensive *body* of gyrating air. Their destructive difference is due to the difference in their velocity of gyration. The important element of the tornado is its spiral movement, and this movement is inaugurated by a local mass of heated air, fed by moist surface currents ascending and forming a partial vacuum, into which the surrounding air is drawn, necessarily acquiring a gyratory motion. There being less resistance in the upper strata of air, this gyratory motion begins there first, and the well known trunk or *funnel* is there initiated and elongated downward, the main and most rapidly revolving mass being above ordinary obstacles on the earth. This column-like downward projection of the tornado cloud is not necessarily at all times visible. Distinguished meteorologists further tell us, that in the central area of the tornado the tendency of the air is spirally upward, as tourists ascend the Tower of Pisa. On the outside of this area, the tendency is downward, and the pressure increases. These opposite tendencies, therefore, produce a closing spiral at the earth end of the trunk, and an opening spiral at its conjunction with the cloud, giving it the shape of an inverted *cone*. This cone is assnmed to be hollow, with quiet and rarified air along its center. Objects drawn into the vortex are raised and hurled outwardly from the ascending whirl. When at times a tremendous rain-fall, or "cloud burst," occurs, it is due to the weight of the water having become greater than the ascensive power of the air that held it in suspension.

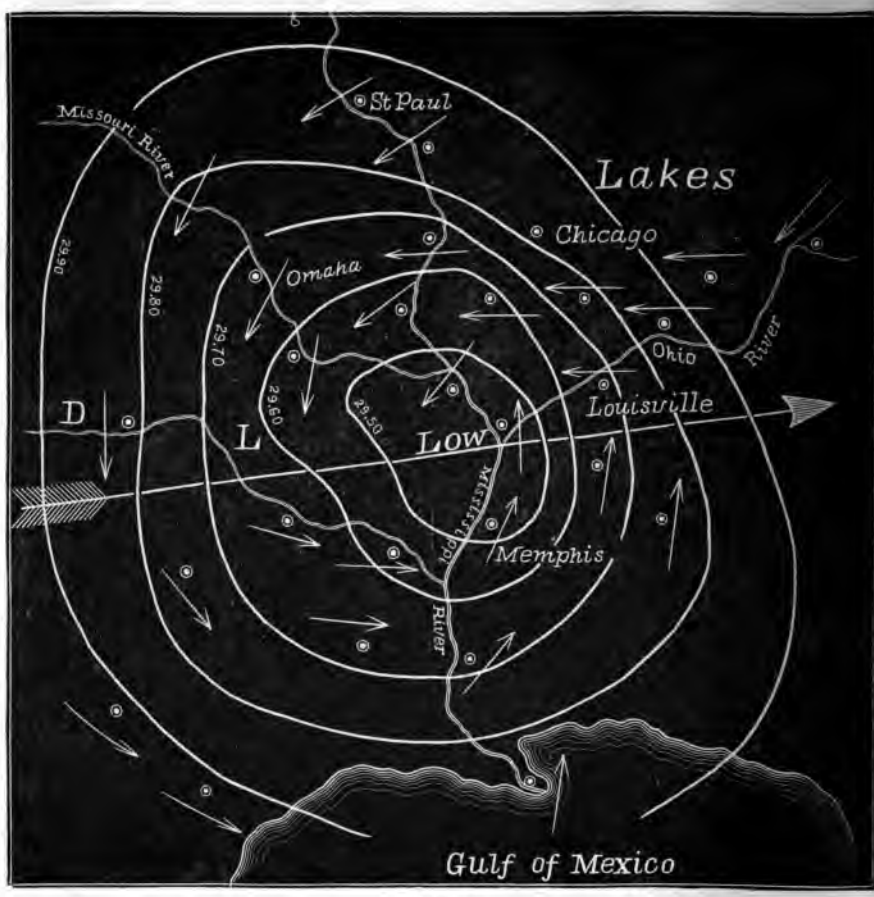
The conditions that are favorable for the production or development of tornadoes, are an unusual elevation of temperature for the season, sultry and electric conditions of the atmosphere, a low barometer, and the conflict of opposing winds of different temperature. They are composed simply

of northerly and southerly lateral currents acquiring a curving direction, the southerly one (in front) westward and inward, and the northerly one (in rear) eastward around and into the center, thus producing a whirl, on the southern side of which trees and other objects are blown toward the *east*, and on the northern side toward the *west*. The direction of movement of tornadoes, which happily are local and short-lived, conform to the general law of all storms—that is, from left to right. The southerly current is the strongest, and covers the greatest area. The tornado is apt to occur immediately after the passage of the lowest barometer. The heated air in front, or on the east (sun rise) side of a vortex ascends, and in the rear the air descends, bringing with it the temperature of the upper regions. This downward sloping rush of colder air, coming in contact with the upward sloping flow of warmer air, the friction and electric action set in motion, produce the tornado, whose incipient formation is in the air above. Like a ravenous bird of prey it descends, striking the earth with an already established gyratory motion around its own center, and then, in accordance with the law of all storm movements, bounds and rebounds with greater or less velocity and destructive force, in a generally easterly direction. There is usually a black and somber cloud ranging perhaps less than a thousand feet above the surface, to which is imparted a gyratory motion, giving rise to a funnel shaped projection of the under surface of the cloud toward the earth, and this terrible funnel or trunk is more or less developed and destructive, according to the condition of the cloud and the character of the locality over which it is being dragged, now apparently fastening its enormous and powerful leech-like mouth upon a grove of trees or a row of buildings, then snatched away and lifted upward by some impulsive movement of its parent cloud, only to sink again to surprise, throw into consternation, and, perhaps, lay in ruins some thriving town that may happen to lie in its path. It has its origin in the enormous electric tension caused by the friction of opposing atmospheric currents of different temperature: and electricity is undoubtedly the active agent producing the appalling effects

of tornadoes. Except in a general way, tornadoes can not be predicted in advance. Their formation or approach may, however, be recognized by local indications. The most marked indications are a sultry, oppressive atmosphere, a peculiar stillness, and the appearance of fierce looking clouds approaching each other from opposite directions. It is the collision of these clouds, borne by opposite currents of air of different temperature, that causes the terrific whirl and the visible funnel shaped tornado cloud. Much has been written about means of escape from the tornado, but nothing that has been suggested appears thoroughly practicable. Cellars, caves or "dug-outs," it is claimed, will afford protection; but it is doubtful whether there is any way of escape, except, when possible, running away from its line of movement, and out of its influence. Fortunately tornadoes are short-lived, and their tracks are narrow.

A STORM'S PROGRESS ILLUSTRATED.

Projecting the weather reports upon a map of the country, as is done on the CINCINNATI COMMERCIAL GAZETTE'S *weather map*, frequently, especially in the fall, winter, and spring months, enables us to inclose by isobars the entire area of a storm movement. This is shown in *Fig.* 6, a diagram of a storm, whose center, at the time, was over the interior of the country. In this way, therefore, does it become possible, by reason of the extent of our country, to get a reasonably early intimation of either an approaching storm or fair weather period—an advancing low or high barometer. Herein lies the value of the weather map, the basis of weather predictions. An inspection of the Signal Service bulletins—or, better still, the COMMERCIAL GAZETTE'S daily weather map, because the latter reveals, at a glance, a synoptic view of the conditions prevailing over sections of the country, whence most of our weather changes come—will show coming changes a day or two, and sometimes more, before their influence is begun to be felt in the Ohio valley. To illustrate the value of the map, suppose a storm has been prevailing. Local indications and conditions in the evening, left us in doubt as to the weather on the morrow—


St Paul
Missouri River
Lakes
Chicago
Omaha
29.90
29.80
29.70
29.60
29.50
Ohio
River
Louisville
D
L
LOW
Mississippi
Memphis
River
Gulf of Mexico

Fig, 6.

Fig. 7.

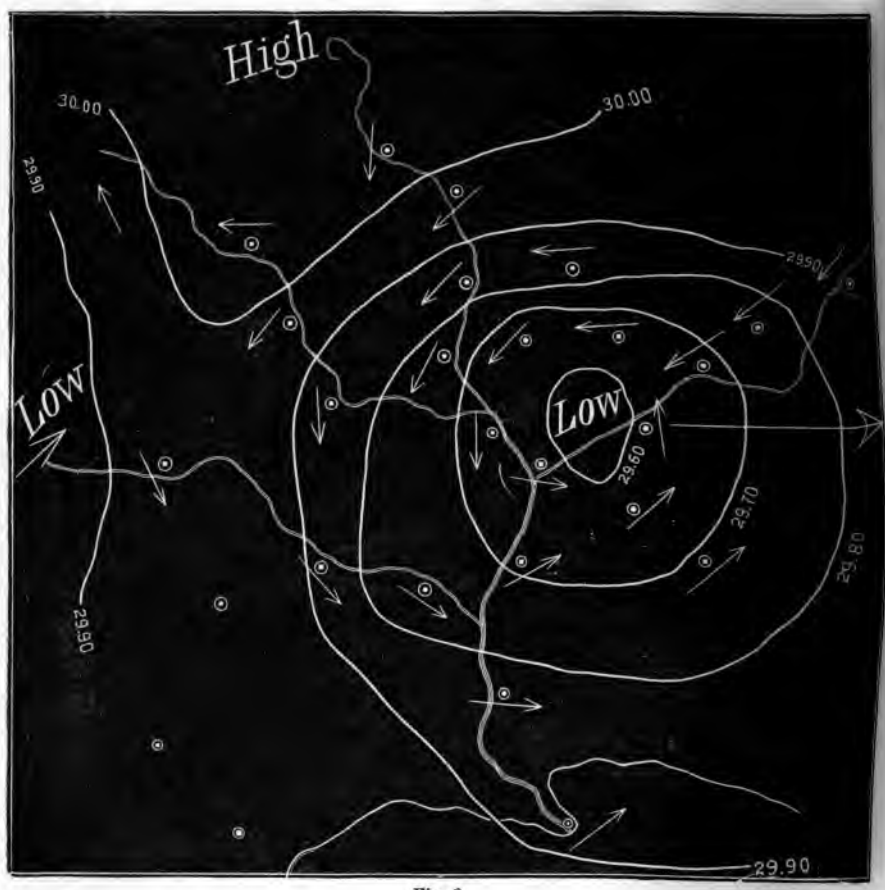


Fig. 8.

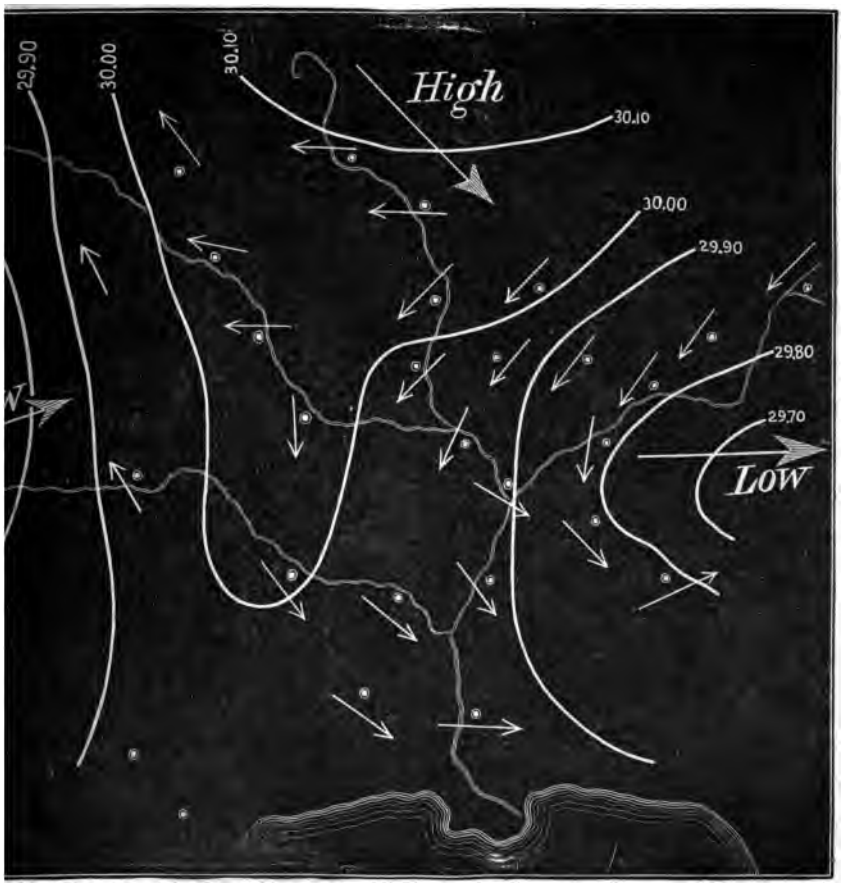


Fig. 9.

for we had south-westerly winds, warm, threatening, and rainy weather. We turn to the map in our paper, on the following morning, and find that conditions, perhaps, somewhat similar to those represented on *Fig.* 4, prevailed during the previous night. Locating the position and extent of the storm area by means of isobars, as explained on page 30, it would at once be seen that the main body of the storm was somewhere over the lower lake region, and moving toward the north-east, and that clearing, cooler weather could be confidently expected during the day, because of the change of wind and rising barometer, attended by clearing and clear weather appearing in the west and north-west.

The series of diagrams, *Figs.* 6, 7, 8, and 9, illustrate the eastward translation of an area of low barometer. Arrows always fly *with* the wind.

On the 20th of April, 1882, the weather reports showed that a storm which had, on the previous day, moved eastward over the lakes with great energy, was passing off north-easterly over the St. Lawrence valley. Its succeeding high barometer, or fair weather, was following it mainly over British America and the Lake Region, moving east and south toward the Middle States. On the following morning, the barometer was again reported low at Dodge City, in Western Kansas (*D*, *Fig.* 6), and another storm center was appearing in that vicinity, as indicated by the isobars, the direction of the winds, and diminishing pressure around it. All regions west of the Mississippi river were already affected by it. The question now was, what course would its center pursue. Further examination of the map showed that the pressure was still high over the lake regions. The approaching storm could, therefore, not move in that direction, because the high barometer there opposed its progress, just as an obstruction in a river would bar the flow of the current and cause it to turn around the obstruction. Storms generally move in a direction north of east; but, in this case, the obstruction prevented it from following the usual course, and it could have been expected that it would, therefore, move almost due east, and that it would, in due time, pass over the Ohio valley. Now, it could with confidence be predicted, that, in regions

east of *D* (*Fig.* 6), the barometer would *fall* during the day, the weather grow warmer and cloudy, with areas of rain. As to the prediction of winds, that was simple enough. South of a region of Low, wherever located, the winds, in general, are *westerly;* east of that region, *southerly;* north of it, *easterly;* and west of it, *northerly.* (*See diagrams.*)

The next report, eight hours later, disclosed the storm center further eastward, occupying the region marked *L* (*Fig.* 6). The central area of the storm could then be definitely outlined on the map. Its influence was beginning to be felt in the Ohio valley. The Signal Service, according to experience and well established rules, predicted increasingly cloudy weather and rain for the Ohio valley. The air in the valley became moister, and the winds grew stronger and more earnest. The air was moving rapidly toward the distant and advancing storm. Railway cars, steam whistles, and other sounds, were heard more distinctly and at a greater distance. All substances influenced by moisture were beginning to indicate the coming rain. There was trouble in lighting fires, and they burned less brightly. Water boiled away more rapidly, as every housewife is aware is the case before or during a storm. In the afternoon, the upper clouds appeared and covered the sky in long, thin, fantastic, feathery layers, stretching far away in the direction in which the storm was moving. The brightness of the sun was affected by the increasing condensation. The moon was encircled by a halo, a very large and perfect one, showing that rain was near at hand. The weather map in next morning's paper showed that, at the previous midnight, fair weather still prevailed throughout the Ohio valley, with continued high pressure in the upper portion of the valley and over the North-east. While the center of the storm was still in the vicinity of *L* (*Fig.* 6), its active influence extended eastward into Indiana, and a general rain was falling throughout the whole Mississippi valley. Easterly winds rapidly moved over the Ohio valley toward the approaching storm, carrying low *scud* clouds along to feed it. From the general conditions represented on that map and local indications, it was absolutely certain that a general rain would prevail in the Ohio valley dur-

ing the day. The question still was, in order to be prepared for any violence that might attend the storm, what course would its *center* continue to pursue. Observing that the barometer was still relatively high over the lower lake region, that the winds continued easterly over the northern sections of the country, with a tendency to work to westward through the north point, and remembering that a storm moves in a path where it meets the least resistance, and along which it is attracted by increasing moisture and rain-fall, it required no uncommon prophetic gift to be able to say, with absolute confidence, that its central area would traverse the lower portion of the Ohio valley.

The afternoon reports of the 22nd, two days after the storm first began to manifest itself as an organizing depression in the Rocky Mountain regions, showed its position and extensive area of disturbance, as illustrated on *Fig.* 6. Eight hours later, *Fig.* 7, shows its further eastward advance, and a high barometer just appearing in the extreme Northwest. After an interval of another eight hours, *Fig.* 8, shows its location and the advance of the high barometer succeeding it, as also evidence of another Low forming in the Far West. *Fig.* 9 represents the outgoing and the incoming Low with a wave, or ridge, of HIGH separating them. A series of weather maps reveal a continual succession of areas of low pressure, or storms, more or less separated by areas of high pressure, or fair weather periods, of varying duration.

SIGNAL SERVICE REPORTS, AND THE FORETELLING OF WEATHER.

Forecasting the weather by the Signal Service system, as has already been shown, is done by taking the atmospheric conditions throughout the country, locating the existing areas of low and high barometer, estimating their probable direction and speed of movement, and announcing, on a basis of well established rules and scientific deductions, what changes in respect to pressure, temperature, wind, and weather are likely to occur in the various districts in consequence of such movement. Any one possessing some knowledge of natural forces, and understanding the nature of the weather, can, with the aid of weather reports, foretell, from

an approaching condition, the character and probable duration of his own local weather. If the prediction based on this system is not fulfilled, there is good and sufficient cause for it. Unexpected changes sometimes occur; retarding, counteracting, or dissipating influences appear; so that, perhaps, entirely different weather may ensue. The mysterious force in nature, which we call low barometer, sometimes performs wonderful freaks, and pursues apparently erratic paths. The Signal Service prediction of general and severe frosts for the North-west, the Lake Regions, and thence southward to Tennessee, on the 20th to 22nd of September, 1823, the mere announcement of which, more especially as it was emphasized by the injunction to "Give utmost publicity," had such a marked effect upon speculation in crops, especially corn, which was then in jeopardy, was a case in point. The prediction was based upon the appearance of a very high and threatening barometer; that is to say, an unusual accumulation of unseasonably cold air in the extreme North-west. No other prediction could have been made under the rules at the time, excepting, perhaps, that it might have been more conservative in tone. The reason for the non-fulfillment of the prediction, as afterward revealed, was simply the appearance of a new storm, whose place of origin was in the lower portion of the Ohio valley, and whose path was northward, but, being barred from making any *easterly* progress by a HIGH overlying the North-east, it curved *westward* over the lake regions. In the meantime, the frost-threatening HIGH in the North-west had pressed down over the regions west of the Mississippi river. The storm now curved *southward*, and fought its way through the eastern borders of the great body of cold air overlying the entire West, and traversing Iowa and the Lower Mississippi valley during the day, attended by heavy rains and violent north-west winds in its rear, returned almost to the place of its origin, thus describing a great loop, after which it slowly passed off north-easterly.

The effect of this unusual movement was to delay, counteract, and in a great measure *dissipate* the high barometer that threatened the frosts predicted.

The country is divided into various meteorological districts, the extent and location of which may be recognized by their designations. Atmospheric waves of disturbance are generally first perceived in the Far West, and then usually move in an easterly direction with greater or less speed, covering successively districts, or portions of districts, according to the latitude along which the center of disturbance moves, and the enlarging or contracting area of the field of disturbance. If the barometer is very low at the center of the storm area, high winds and severe gales will prevail over an area of country of about two hundred miles radius during the winter months, and probably less than one hundred miles during the summer months. There is an old saying—

> "If the glass falls low,
> Prepare for a blow."

If an energetic storm center is located in Dakota or Minnesota, with a considerable extension of the storm area southward across the Missouri valley, the whole traveling eastward, the winds in the Ohio valley will be successively south-easterly, southerly, south-westerly, westerly, and north-westerly, as the depression in the north passes to the eastward of our meridian. The depression having passed into the North-east, or the St. Lawrence valley, an opposite condition, or area of high barometer, will follow, coming perhaps from over the Rocky Mountain regions, or perhaps from western British America. If from the latter, and it pursues the usual south-easterly path of high pressure areas, we can prepare for a change in temperature, possibly, according to the season, a severe cold wave, and our winds will continue to shift around the compass in the regular way; that is, to north, north-east, east and south-east, when evidences of another depression will very likely again be seen in the reports from the Far West. In this case, we will have a period of fair weather, whose duration may be known by the character, extent, and rate of movement of the high barometer causing it. If the wind is northerly and steady, and the sky becomes clear and bright,

we need expect no change of weather until we see the forerunners of the next storm, in the form of streaks of cloud appearing above the horizon of the western semicircle. In winter, the storm will follow the first appearance of these thin, hazy, feathery clouds in several days; in spring and autumn generally in about one day. Now, if our barometer, or the pressure in our locality as shown by reports from neighboring stations, is high and steady for some time, there is a surplus of air, the weather will be dry and fine, and no disturbance can take place. The passage of an area of high barometer over a given locality may occupy several days, or a week—occasionally longer—from the time that "first rise after low" (which foretells stronger blow") reaches the locality until the next rain. Or, if the high pressure was of rapid birth, and unsteady character, it may pass away or become dissipated very quickly. Weather waves may be likened to the waves of the ocean, sometimes grand in their proportions, and steady and regular in their movement; at other times choppy and uncertain. Storms, areas of *low barometer*, have a warm or hot area on their east side, with easterly or south-easterly winds, and a cool or cold area on their west side, with northerly or westerly winds. If a storm is central in the upper Mississippi valley, the highest temperature of the month may occur in the Ohio valley, while the lowest temperature of the month prevails in the Missouri valley. We may be sweltering in a moist atmosphere of 80° or 90° on the hot side of a storm, and in a day be subjected, all unprepared perhaps, to the chilling winds and cold air following the storm. In this matter, at least, we can know what "a day may bring forth," and there is no excuse for our disregard of the changes that are inevitable: changes sometimes sudden, great, and fatal, bringing disease and suffering and death, results that may be avoided by proper precautions.

The Signal Service, then, is able to announce, with general accuracy, what the weather indications are, from day to day, in the various districts, by keeping itself well informed of the movements of low or high barometers, and the influences opposing, retarding, or modifying such movements. Storms

traverse the country along higher or lower parallels, according to the season of the year, caused by the difference of the earth's position to the vertical rays of the sun. In winter and early spring, these storm paths lie along lower latitudes, and we look to the *south-west* for indications. The lower the line of transit, the colder our winter; because the cold northerly air, in the rear of storms, preponderates. In the latter part of spring and early summer, these belts of condensation have moved further north, with the apparent motion of the sun; and we look to the *west* for indications. In summer and autumn they are in the north; and the further north, the warmer our summer and longer our autumn; because the warm southerly air, in their *front*, preponderates. We then look to the *north-west* for indications. If a south-western low appears, it is likely to travel eastward, or north-eastward, across the country, according to the most favorable conditions in its front. East and south-east to south-west winds, warmer, increasingly cloudy weather, and rain, will successively prevail over the regions in front, or on the east side, of its line of march; while north-east to west winds and colder weather, with clearing rains, caused by the cold winds underrunning and changing the previous current, will follow as a belt of cloudiness, generally moving *south-eastward* over the country. If this movement of the cool wave (advancing high barometer) is slow, and clearing weather does not set in as quickly as anticipated, it is because there is high pressure in the south opposing its progress. If a western low appears, it is likely to move in some easterly direction, attended by the same system of winds and weather—the circulation of the wind being clearly shown on Figs. 6, 7, 8 and 9. If a northwestern low appears, it is also likely to move eastward over, or north of, the Lake Region. Our warmest weather, and periods of drouth, are in connection with storms passing by in the far north. Very often the conditions following a storm, in such case, do not reach us. Storm centers seek moist, warm regions, where the pressure gives way most readily; and the force of the wind in any locality depends mainly upon the rapidity with which the pressure is changing, decreasing in front, and increasing in rear, of the storm.

The Signal Service predictions are reduced to the simple "determination of the path pursued by the central area of low pressure, and the rapidity with which this will extend its influence in any given direction."

Local intimations of the approach of a storm, even without instruments, are abundant, and easily read. In a period of bright, clear weather, when the atmosphere is in a normal state, we are under the condition of high pressure; and this can be distinguished very readily by our feelings alone. This fair, pleasant, and agreeable condition gradually passes off with rising temperature, haziness, growing dampness, freshening southerly winds, and increasing cloud formation.

There is a storm somewhere in the West, and its influence is slowly extending over us. The increase in temperature is a sure sign of an approaching storm. It shows that the central area of high barometer has passed beyond us, and that the southerly current is again sinking to the surface, and warming up the earth and lower strata of air. More or less haziness may attend this change, which, counteracting the tendency to cloud formation, may prolong our fair weather. Then, as the storm or rain belt approaches nearer, evaporation ceases—we feel the humidity of the air increasing, in consequence of the rising temperature and the prevailing wind. The barometer is gradually falling; the thready cirrus clouds appear; condensation increases; the wind freshens, blowing toward the coming storm; our feelings begin to tell us of the approaching change; the air begins to feel close and sultry; animals become restless; all substances affected by moisture show the change; odors are concentrated; fires do not burn brightly; water boils more rapidly; halos appear; distant lights are brighter, and sounds more distinct; there is a *foul* sunset, and rain is evidently at hand. High pressure, with its usual attendant, fair weather, has passed away, and low pressure, with its foul weather, prevails. Meanwhile, the weather map or weather reports will have kept us informed just where the Low was central, from time to time, and whether the center of the disturbance, or only the borders, and which borders, of its area were approaching our locality. When we consider the importance and utility

of practical weather knowledge, it is surprising that a portion of the time and effort devoted in our schools and universities to acquiring a smattering of sciences that have little or no practical bearing upon the ordinary pursuits of life, is not applied to a study of those that have, prominent among which is meteorology—the science of the weather, the study of the atmosphere. The time when mere notions and superstitions respecting the weather had possession of men's minds has passed by.

The relative positions of the planets, the changes, phases, and appearance of the moon, the actions of the ground-hog, the beaver, or the intelligent pig, the gabbling of geese, and the migration of birds, all old-fashioned "signs," have been superseded by a steadily increasing knowledge of the laws governing the wonderful phenomena occuring in our atmosphere. Effects have been traced to their causes. Drouths or wet spells, excessive heat or cold, storms or sunshine, are susceptible of explanation, anticipation, and, therefore, preparation against their coming. The wind no longer blows where it listeth. We know whence it comes and whither it goes.

The study of meteorology would soon place students in possession of inductive generalizations, that would give them an insight into the nature of the changes that are constantly taking place. The weather map—reports from different places of pressure, temperature, moisture, wind, and cloudiness, projected upon a map of the country, or even the common blackboard, is an object lesson second to none in point of interest and value. The Government furnishes these reports every eight hours. They could be multiplied for distribution among learners, for practical work in connection with the study of the subject, and for purposes of prediction of local changes. In connection with the study of the textbook, time and practice in locating the fields or areas of different weather, over the country, as shown by the reports, would soon enable the learner to comprehend the processes of nature, and the ever-moving weather conditions.

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